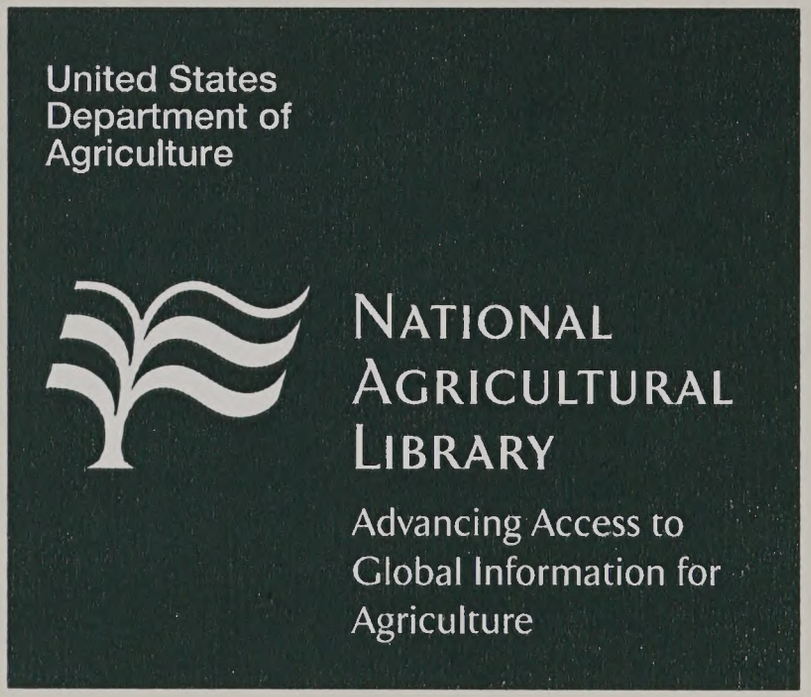
A National Program of Research for

WHEAT AND OTHER SMALL GRAINS

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES



FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

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INTRODUCTION

Wheat and Other Small Grains Research Needs Through 1977

AUTHORITY: A Joint Task Force to study the research needs associated with wheat and other small grains was appointed March 11, 1968, by Dr. George L. Mehren, Assistant Secretary of Agriculture and Director A. G. Hazen, Chairman of the Experiment Station Committee on Organization and Policy.

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ASSIGNMENT AND BACKGROUND: A long-range study of agricultural and forestry research was undertaken at the request of the Senate Subcommittee on Agricultural Appropriations. It was initiated through the cooperative efforts of the Secretary of Agriculture and the Chairman of the Executive Committee of the Association of State Universities and Land-Grant Colleges (ASULGC). Representatives assigned by USDA and the Experiment Station Committee on Organization and Policy (ESCOP) conducted the study and prepared their report entitled A National Program of Research for Agriculture. The report aggregates agricultural and forestry research into 91 broad problem areas and recommends for each level of program to be attained in 1972 and 1977, 5 and 10 years after the completion of the study. The Secretary of Agriculture and the Chairman of the Executive Committee, ASULGC, jointly submitted it to the Senate Committee on Appropriations on October 13, 1966.

The report proposed further analysis of each of the 91 problem areas. At its July 1966 meeting, the Agricultural Research Planning Committee (ARPC) took steps to partially implement this proposal by recommending that the Department and State Agricultural Experiment Stations establish several task forces for study of significant segments of agricultural research.

Within the general framework of the long-range study, this Task Force was charged with indicating areas of research which need emphasis and with determining the most efficient procedures for organizing and carrying out the specific research involved. Taking present arrangements into account, the Task Force was asked to recommend a reasonable division of responsibilities and effort, and suitable organizations for conducting the program.

SITUATION: The small grains occupied 32% of the acreage seeded to crops in the United States for a total of 102,352,000 in 1967. Individual crop acreages were as follows: Wheat - 68,015,000; Barley - 10,012,000; Oats - 20,611,000; Rye - 3,667,000; and Buckwheat - 47,000. Triticale was not grown commercially.

Wheat is extensively grown in the United States, is widely used as human food, and constitutes one of our greatest agricultural exports. Wheat farmers are caught in a narrowing cost-price ratio; therefore, a large effort should be made to develop practices that will enable farmers to produce and market a better crop at lower costs. To do this, basic information is needed on plant, soil, management factors, and other elements involved in producing high

yields, more resistance to insects, diseases, and other hazards, more nutritious grain and better marketing practices and opportunities. With the knowledge that heterosis exists in wheat, more attention should be turned toward developing hybrid wheats that may be utilized profitably and which have good quality. A vast number of questions need to be answered. Urgent biological problems present themselves in our continuing fight to control pests of wheat, and to determine the factors and the types of gene action involved in heterosis, the mechanisms of sterility and restoration of fertility. Mutations and/or gene interactions that go to produce new and higher levels of nutrition, need to be studied along with ways to stabilize improved quality. Continued emphasis on market quality and consumer acceptance of wheat and wheat products is essential to maintain current use patterns and to expand utilization of wheat.

Barley yield and quality fluctuate with changes in certain factors such as climate, soil, diseases, lodging, winterkilling, shattering, drought, and insect damage. Commercial processing procedures for the production of malt and malt liquors are undergoing changes at the present time, and this raises the question of the suitability of presently used varieties for these purposes. The constant replacement of new varieties for older ones and the changes in processing procedures by industry for producing malt and malt liquors call for an even greater awareness in the suitability of the new varieties for industrial use. This problem will be increased when hybrids make their appearance. Diseases continue to cause greater losses in barley. They lower the quality of the grain and restrict the area where high quality barleys can be grown. Additional work needs to be done to measure the amount of hybrid vigor in barley, to determine factors that will increase cross-pollinations, to learn the relation of mitochondria to heterosis, to find other or alternate systems for producing hybrid seed, to study the effect of hybrid vigor on quality, disease, and insect resistance, and on field managerial procedures geared to reduce the cost of seed. Increased efforts on basic research are needed in genetics, cytology, pathology, physiology, and breeding methods to provide information to strengthen the breeding programs, the work on quality, and to provide a fuller understanding of the nature of winterhardiness, aluminum toxicity, host-pathogen relationships, and the relation of molecular structure to gene action.

Oats is the Nation's third largest cereal crop. However, there is uncertainty of oat production because of the susceptibility of the crop to diseases and insects, and to weather damage. Much progress has been made in yield, quality, and disease resistance. There is a continuing need for basic information on the effects of fungus and virus diseases on winter survival, yield, and quality, and the effect of environmental factors on disease development and damage. Much remains to be learned about the pathology, biochemistry, and epidemiology and control of these diseases. Winterhardiness in oats is an urgent factor to be improved. Yield, quality, and balance of the amino acids and vitamins of oats can be improved. The discovery of high protein oats places oats in a potentially improved position as a major crop and as a major source of high protein food and feeds for overseas as well as domestic uses. As these desired characteristics are based on heritable traits and

appropriate inheritance and breeding studies are made, oats as an agronomically desirable, disease resistant, and nutritious grain crop will become more valuable and more widely used.

Buckwheat is a minor crop; its improvement has been postponed. To make it profitable to produce this crop, the quality will have to be improved and the yield increased, perhaps doubled. Disease resistance, grain quality, and adaptation of the plant to various environmental and cultural practices would help to make buckwheat more desirable for crop production.

Triticale is a man-made crop from wheat x rye crosses with doubling of chromosomes. Sporadic work for 75 years has yielded nothing of practical significance. However, recently developed early, short, disease resistant, more fertile types have been isolated with renewed hope that a practical feed grain crop may be available soon.

Rye as a grain and forage crop has largely been disregarded in research. The grain yield is low, plant type is unimproved and forage yields are variable. Disease and insect problems peculiar to the crop take their toll annually.

Farmers have tended to produce larger tonnages of wheat and, locally, the other small grains, than can be profitably utilized. Despite continuing severe acreage restrictions, wheat production persists at record levels -- the 1968 crop is projected at slightly more than 1.6 billion bushels. Total domestic disappearance is steady at about 700 million bushels because of falling per capita food consumption, insignificant industrial consumption, and seesaw, but limited, feed usage. Exports have exceeded domestic use and, with intense promotion and concessional assistance, have twice exceeded 750 million bushels. Carryover stocks have often led to burdensome supplies. Economic and other pressures for expanded utilization of wheat in foreign and domestic markets are therefore heavy and are increasing. This situation for wheat will continue into at least the near future and the outlook is similar for the other small grains. Common sense demands, therefore, that a concerted research and merchandizing effort be directed toward increasing wheat usage as food, feed, and industrial products, both domestically and overseas, to create an active market to match our efficient producing capability.

Increased exports deserve particular emphasis because wheat and the other small grains each contribute substantially and positively to our balance of foreign trade and are presently meeting stiffening competition in major dollar markets.

In connection with world food shortages, it is important to recognize (1) that the primary deficiency is food calories and (2) that protein shortage is a secondary, though vital, deficiency. Cereal grains already provide the majority of the world's food calories, and wheat provides more food protein than any other single commodity. As new and exotic food protein sources become significant commercial entities, they most desirably will enter diets in a vehicle provided by cereal grains. Appropriate product development research is therefore urgently needed.

Research is needed to help keep product quality high and avoid further losses in per capita consumption and to help keep product costs low. Although relative prices, particularly at the farm level, determine how much wheat is fed to poultry and livestock, feed usage ranks a poor second to food usage. Feed usage is the major outlet of the other small grains. Processing to achieve more of the total potential feed value inherent in these grains is needed to help keep consumer prices of meats and related products low and to increase returns to growers and other feeders.

The increasing use of frozen and refrigerated food products, based on or using cereal flours, imposes new and stringent microorganism limits on the grain processing and using industries. Full knowledge is therefore needed about sources of microbial contamination, its control, and its elimination through all phases of processing from the flour mill to the consumers purchase of the wide variety of end products. Similarly, research directed toward elimination of actual or potential pollution of air, water or soil by processing of grains should be undertaken. Effluents from the wet processing of wheat flour, and from grain washing are examples, and new problems of this type are expected as cereal processing becomes more diverse.

The grain industry handles larger lots, uses more automation, and is requesting faster and better grain inspection service and superior grain quality maintenance and protection in marketing than ever before. Criticism of our wheat grading and inspection methods by foreign buyers continues. Buyers demand a wheat grading and inspection system that will reflect the end use value of the grain. This also holds true for barley and oats. Industry is demanding the development of a complete automatic grain grading and inspection system.

Handling larger grain lots at higher velocities tends to increase grain breakage with resulting deterioration and a reduction in grade. Broken grains are more susceptible to attacks by molds and insects. Wheat and other small grains are harvested at faster rates each year resulting in a tremendous flow of grain into large storage facilities in a short period of time. Conventional grain drying and handling equipment is inadequate to condition the grain in the time required. Design criteria and techniques should be developed for faster and less costly grain handling and conditioning equipment that will not damage the grain. New basic knowledge on the rheological, physical, electrical, and optical properties of the grain is required.

Insect infestation and damage is estimated to cause a loss of three percent of the total wheat production. This loss occurs despite the annual expenditures of an estimated $5.6 million for control and related costs. Present losses, costs and control measures cannot be considered static. Some fumigants now in common use may not be permitted in the future. For example, the Food and Drug Administration announced in the Federal Register early in 1968 that carbon tetrachloride may not be sold for household or domestic use because of its hazard to health. This will cause toxicologists to review its use as a grain fumigant. Carbon tetrachloride is not permitted for fumigating grain in Germany. Carbon tetrachloride is a major component of all U.S. liquid grain

fumigants and there are no suitable substitutes or alternatives.

The discovery of higher protein oats, wheat and barley has emphasized the need for the development of a fast, reliable, and economic method of determining protein content and protein nutritional quality. Development of such a method would have world-wide significance.

Despite the amount of effort devoted to controlling molds in grain during storage there are still many questions unanswered. Recently, the problem of mycotoxins has arisen. Even though this has not been a major problem in wheat, barley or oats, we still should know how different microorganisms respond under different conditions on these grains and determine under what conditions the production of mycotoxins will or will not occur. With the development of more accurate and precise methods of detecting mycotoxins it is possible that they could start showing up in grains heretofore undetected.

The recommended research effort in market quality should significantly increase our ability to cope with problems in grain sampling and grading, to control molds and insects, to reduce grain breakage, and to develop more meaningful quality factors suitable for marketing wheat and other small grains. Ample returns are expected from the application of these factors through appropriate methodology and development of new design concepts and criteria for handling, storing and transporting grain.

This Task Force recognizes the continuing and accelerating influences of increasing population, increasing urbanization, and progressive loss of fertile agricultural land. Despite the potential surplus situation in U.S. cereal production, prudent long-range concern for the well-being of both the consumers and producers requires that research in protection, production, utilization, and marketing of wheat and the other small grains be vigorously, supported.

PRESENT EFFORT: In 1966 it was estimated that 367 scientific man years of effort were expended on these five crops in the United States. This was almost exactly equally divided between USDA and SAES. An undetermined amount of private effort was expended. The public agency work was widely scattered averaging less than 1 SMY per year at State Experiment Stations and about 1.5 SMY per Federal location. Research on protection and production were the most disperse and utilization research was the most concentrated. In general, Federal personnel are given narrower subject matter and broader geographical assignments than State personnel. Averages and such generalities are indicative only and do not represent idealized situations.

FUTURE EFFORT: It is believed that future small grain research should follow the general philosophy of the present, i.e., State and Federal agencies should engage in basic and applied research and freely share the findings with private agencies, farmers, seedsmen, etc., with the main job of development always resting with the private sector. It is apparent that industry

desires to assume more responsibility in variety development, production schemes, mechanization, industrial processing, and marketing. Indeed, industry has always taken a strong position of leadership in these and other aspects of agricultural development. Recommendations made by this Task Force are within this point of view.

RECOMMENDATIONS: A healthy small grains industry must meet the demands placed upon it for food, feed, and industrial products, and do so with a reasonable return on investments in land, labor and capital. It must have resources, and be provided through research with information, materials, and processes by which to be efficient and competitive in domestic and foreign markets. Therefore, this Task Force makes the following general recommendations:

1. Research of increased magnitude as given in the accompanying table is both needed and compatible with the returns to be expected and is recommended. The projected research as indicated by total manpower in 1977, when set off against the acreage of these crops or their total volume and worth, appears small. For example, only 6 SMYs per million acres is projected for 1977. It is about half (3.6) that at present. Somewhat larger projections than those suggested by NPRA are documented in the specific objectives in this report. They surpass the NPRA figures for protection by 28, for production by 21, for utilization by 4, and for marketing by 32.

Manpower Projections (SMY)

RPA	NPRA			Our Task Force	
	1966	1972	1977	1972	1977
PROTECTION:					
207 Insects	36	44	53	44	53
208 Diseases	69	85	102	101	122
209 Weeds	10	16	20	18	28
PRODUCTION:					
307 Biol. Efficiency	107	129	188	145	178
308 Mechanization	4	-	-	4	6
309 Systems Anal.	1	-	-	7	15
405 Quality Eval.	21	29	41	43	51
UTILIZATION					
406 New food use	45	47	51	41	49
407 Non-food use	36	36	36	38	42
MARKETING					
408 Mkt. Quality	24	26	29	36	46
501 Grades	3	3	3	9	10
504 Mkt. Efficiency	11	11	12	19	20
TOTAL	367	426	535	505	620

2. Research to stabilize farm production and make management more efficient is essential and recommended. The control of weeds, insects and diseases is a heavy drain on the production budget and ways to alleviate these losses through research seem a bright prospect. Ways should be sought to increase acre yield through increased biological efficiency.

Management practices are being changed by research to increase production, by intensifying farming practices, decreasing diversification, reducing crop rotations, increasing fertilization, increasing irrigation, changing plant morphology, and developing hybrids. These changes in management practices are altering pathogen, weed and insect populations. Pathogens which have not been important are becoming more prevalent. We recommend additional research to identify changes associated with the new management practices, and to develop methods for controlling those pests which become prevalent.

Systemic fungicides and insecticides, compatible with other pesticides, relatively inexpensive, easy to apply, non-phytotoxic, and which show satisfactory increases in seed yield and quality have recently become available. We recommend additional research on these and other chemicals for controlling pests.

The yield, quality, physical traits and other characteristics of the small grains grown on millions of U.S. acres are the result of a continuing interaction between the genotype of the plant and its changing total environment; in fact, they are the result of a sequence of biochemical reactions monitored by enzymes, themselves under the control of genes. This whole area of the physiological ecology of the cereals is not well understood; high yielding varieties have been bred without fully understanding why they are superior in performance. For progress in the future, it is essential that favorable plant metabolic processes be recognized and used in variety development and crop production.

Biological efficiency involves research on a host of important subject areas including basic biological processes, morphological traits, response characteristics and genotype-environment interactions. These traits should become as well known and as useable in plant improvement as are, for example, genes for height, disease reaction and stiff straw. Regional or national plant physiology laboratories are needed in which critical research may be conducted on cell organization and plant growth, enzyme activities and systems, gene action and energy transfers, photosynthesis and light reactions, physiological response to stress, such as cold, heat or drouth, mineral nutrition, efficient morphological architecture of leaves, roots, stems and heads, and population structure as it affects crop performance.

3. Research to improve and to stabilize quality of grain and primary products from grower to consumer is urgent and recommended.

A substantial increase in quantity of high quality protein in some cereal crops is of the greatest necessity for adequate nutrition of humans and livestock throughout the World. Nutrition specialists everywhere proclaim that

the greatest contribution to good health would be a substantial increase of a balanced protein in cereal crops which are now eaten and relished in their human diets. Priority for high quality protein cereal grains is being expressed by all importing countries of the world and the achievement of this objective would enhance quality and greatly increase exports of U.S. cereal grains.

The maintenance of quality and its proper identification at all levels of development, production and marketing is of the utmost importance for assurance of steady or increasing outlets of small grains in foods, feeds, beverages, or by-products.

4. Research to expand markets is strongly recommended. It should be vigorously pursued on a broad front. Low-cost production, efficient marketing, competitive prices, and attractive products all make a contribution to this objective and thereby all RPAs (and others) discussed in this report become significant. New food and industrial products, improved raw and processed grains and their by-products are worthy of aggressive research. Specific foreign market development work (involving RPA 601), protection of food supplies from microorganisms (RPA 702) and problems of pollution control (RPA 901) also are pertinent to the objective. It is of very great importance to the Nation's economy to increase exports, to protect food, and to avoid pollution of food and feed and our environment. The economic magnitude of wheat and the other small grains and the associated industries must be kept in mind when assigning priorities to agricultural research in order to keep our country strong and to make an adequate contribution to world trade.

5. A concerted effort should be devoted to the development of an automated grain sampling and grading system so that grading systems reflect and use value of the grain or product. The development of fast, reliable, and economical methods to determine the quantity, functional, and nutritional value of protein in wheat and other small grains is worthy of intensive research. An intensified research effort be made to devise new methods of controlling insects and molds in wheat and other small grains.

Impetus should be given to basic and fundamental studies on the rheological, physical, electrical and optical properties of wheat and other small grains with the objective of developing new and improved design criteria for grain conditioning and handling equipment, development of new techniques and methodology for grain sampling, grading and inspection, and improved procedures for maintaining the quality of the grain during storage, transport and handling.

In furtherance of market quality research, it is recommended that the U.S. Grain Marketing Research Center, now in thefinal architectural stages, to be built at Manhattan, Kansas, should be given high priority and that Federal market quality research on wheat and other small grains of the sort enumerated in this recommendation be centered there; and that this laboratory coordinate research work of this type done by State institutions and private

businesses, as appropriate.

6. The research outlined here affects crops grown over very large geographical areas; much of the research has regional and national impact. Therefore, every opportunity should be provided to foster regional effort and this Task Force so recommends. We believe this approach is necessary in order to conserve man power, budgets, and facilities, and to produce comprehensive research results.

Small grain research generally involves direct cooperation between USDA and SAES scientists and often involves the private sector also. Various research divisions of the Agricultural Research Service and the Economic Research Service, USDA, are extensively involved in this kind of cooperative research effort with SAES workers concerned with wheat and other small grains. Thus, there are many regional concentrations of research effort. Regional variety tests, regional attacks on pest problems (both entomological and pathological), germ plasm maintenance, and the quality laboratories are typical examples. The utilization laboratories represent another kind of regional effort whereby enough emphasis can be given to single problems to be effective.

It seems certain that regional research effort should expand. Not only will there be additional teaming of scientists, there likely will be more sharing of research facilities. Proper planning of both SAES and USDA facilities will be necessary for efficient utilization.

RESEARCH PROBLEM AREAS FOR PROTECTION OF CROPS

TITLE: Biology, taxonomy, physiology, and nutrition of insects. RPA 207-A.

SITUATION: More than 100 species of insects cause over $200 million damage to wheat and other small grains each year in the United States. Information on the life cycle, migration, host range, and other biological, ecological, and physiological characteristics of each major insect is needed to develop adequate chemical, cultural, biological, and other methods of control. A thorough knowledge of the life cycle and development of insects may reveal "weak links" in stages of growth at which specific control measures would be most effective. Insect identification (taxonomy) is the key to previous literature and the foundation for basic and applied entomological research.

OBJECTIVE: To determine the life history, distribution, abundance, damage, nutritional requirements, and other biological, physiological, and ecological characteristics of insects which may be of value in developing control measures.

RESEARCH APPROACHES:

A. Laboratory, field, and cage studies will be used to determine mating, feeding, migration, preference for alternate host plants, and population dynamics of major wheat and other small grain insects, and from this information determine life tables for different ecological areas.

B. Determine the physiological processes of insect development and interpret and evaluate such information as a possible means for development of methods to interfere with or interrupt insect growth and reproduction.

C. Conduct taxonomic studies of all developmental stages of insects as a foundation for valid identification procedures.

D. Determine the effect of various insect populations at different times and under different growing conditions on yield and quality of wheat and other small grains and determine the economic injury thresholds.

E. Develop methods of rearing wheat and other small grain insects or artificial media so that nutritional requirements can be refined and mass rearing methods developed.

POTENTIAL BENEFITS: Direct benefits will accrue from reduced cost of production by better timing of all control practices. Residue hazards will be reduced.

RESEARCH EFFORT:	TF RECOMMENDATION	
	1972	1977
	9	10

TITLE: Control of insects through the development of resistant varieties. RPA 207-B.

SITUATION: Public opposition to the use of pesticides continues to become more intense. The appearance of resistance to certain insecticides in some wheat and other small grain insects stresses the need for alternate methods of control. The development of insect resistant varieties of wheat and other small grains carried out in joint research between plant breeders and entomologists provides an effective, economical, and safe way to deal with many insect problems. This has been a highly successful approach for control of several insects attacking wheat and other small grains. The time required to complete research leading to the development of effective and acceptable resistant varieties is one of the major limitations to this means of insect control. The development of insect resistant varieties must be a continuous program, because strains of insects often develop which can attack varieties which were previously resistant. Therefore, germ plasm must be located that is resistant to new strain of insects and this resistance incorporated into new varieties. Resistance varieties can often be a part of integrated control methods, since varieties with only a moderate degree of resistance can be used to supplement biological, cultural, chemical, or other control methods.

OBJECTIVE: To identify sources of insect resistance in wheat and other small grains, determine the cause of such resistance and the mode of inheritance and transfer this resistance to productive well-adopted varieties.

RESEARCH APPROACHES:

A. Collect and evaluate wheat and other small grain germ plasm for insect resistance.

B. Conduct breeding and selection programs to transfer resistance to productive, well-adapted varieties.

C. Combine resistance to different insects into one variety.

D. Determine the effect of resistant varieties after released on the over-all population of the insect in the area.

E. Study the inheritance of host reaction to insects and insect virulence to host plants.

F. Determine the presence and the relative abundance of different physiological races of the insect before and after resistant varieties have been released.

G. Determine the chemical, physiological, or morphological nature of resistance and the inheritance of these factors.

POTENTIAL BENEFITS: Reduced cost of production and increased yield and quality plus reduced need for chemicals are potential benefits. Reduced hazard to beneficial insects and wildlife, and reduced air, food, soil, and water pollution are added benefits. Insects cause extensive loss to wheat and other small grains each year; also, large sums of money are spent on control. If productive varieties could be developed with resistance to the major insects, at least one-half of the loss could be prevented and the residue hazard would also be reduced.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
14	16

TITLE: Cultural practices for insect control. RPA 207-C.

SITUATION: Modification of planting, growing, harvesting, or the utilization of other agricultural practices to prevent or lessen insect damage to wheat or other small grains may be of great significance. A thorough knowledge of the life history of a pest species is essential in developing cultural control methods. Crop rotation is effective for insects with a restrictive food habit or those having limited powers of migration. Some species of wireworms, several mites, and the wheat strawworm are examples of pests which can be controlled by rotation. When cultural control practices are also desirable agronomic practices, they are usually readily adopted. However, when cultural controls are poor agronomic practices,it is necessary to carefully weigh the advantages and disadvantages before these methods should be recommended. Cultural practices alone may not give completely satisfactory insect control, nevertheless they are often important in minimizing injury, and should be considered in any area-wide integrated control program. When good cultural control practices are followed less insecticides or a reduced number of applications may be necessary for control. If entomological research on cultural control is to keep pace with agronomic production research, the entomologists must work cooperatively with all scientists who are concerned with wheat and other small grain production.

OBJECTIVE: To determine the effect of tillage practices, fertilizer, crop rotation, crop refuse destruction, water management practices, land utilization, time of planting, and harvesting procedures on insect population

dynamics.

RESEARCH APPROACHES:

A. Evaluate the effect of time of planting, method of planting, and method of seed bed preparation, on insect population and damage.

B. Study the effect of various crop rotation and crop residue management practices on the insect population.

C. Determine the effect of application of different fertilizers and irrigation practices on insect infestations.

POTENTIAL BENEFITS: Lower cost of production and increased yield and quality are primary benefits. Reduced need for chemicals and improved environmental conditions would also be fostered. Approximately one-fourth of the annual losses due to insects could be saved by development of cultural control practices.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
2	3

TITLE: Biological control of insects. RPA 207-D.

SITUATION: Biological factors such as parasites, predators, and diseases often play a major role in reducing insect populations. The basis for most biological control research lies in the fact that many of the injurious wheat and other small grain insects in the U.S. have been introduced from foreign countries without the parasites, predators, and diseases that attacked them in their native land. Thus, the objective in most cases is to import parasites, predators, or insect pathogens from the insect's native home and establish them throughout the range of the pest in the United States, and thus reduce their hosts to the approximate level that occur in the country of origin.

In recent years cheaper and more efficient methods have been developed to mass produce insects in the laboratory. It has sometimes been possible to use these mass-produced insects to rear large number of parasites for field release. No extensive research has been conducted on the control of wheat and other small grain insects by mass release of parasites and predators. Under some conditions naturally occurring diseases may terminate what appeared to be an extensive insect outbreak. There is need for research to determine if such insect pathogens can be propagated in the laboratory and disseminated by man to control these insects.

OBJECTIVE: To make maximum use of parasites, predators, and insect pathogens in controlling insects attacking wheat and other small grains.

RESEARCH APPROACHES:

A. Search for parasites, predators, and pathogens of insects in their native home and when found propagate, introduce, and disseminate these agents in the area where the host insect occurs in the United States.

B. Evaluate the effectiveness of both native and introduced parasites, predators, and diseases for the control of major insects in the United States.

C. Develop techniques for mass production and release of parasites, predators, and insect pathogens to evaluate these organisms for field control.

POTENTIAL BENEFITS: The development of more effective biological control methods could reduce the annual insect loss by one fifth and also reduce insecticide residue hazards. Lower costs of production and less dependence on insecticides would result. Beneficial insects could be protected and the quality of our environment improved.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	7

TITLE: Chemical control of insects. RPA 207-E.

SITUATION: Discoveries of new synthetic insecticides and improved methods of applying them have made it practical to use insecticides to control many insects attacking wheat and other small grains. Insecticides will continue to be the first line of defense against many of these insects. However, several insects have become resistant to insecticides that formerly gave satisfactory control. Some insecticides reduce the population of beneficial parasites and predators and may kill wildlife. Although tolerances have been set for several insecticides on wheat and other small grains, these tolerances may not be accepted internationally thus affecting the export market. Because of these factors, research is needed to find materials that possess maximum biological activity against the target insect with a minimum of biological activity against man, animals, and other useful organisms in the environment. Special emphasis should be devoted to a search for insecticdes that are not persistent and which do not accumulate in plant and animal tissues and subsequentlymagnify through food chain organisms in the tissue of animals.

Since many residue problems arise from insecticide drift to non-target areas there is need for improved formulation and insecticide application equipment.

OBJECTIVE: To develop cheaper and more effective chemical control methods that will leave no objectionable residues, cause minimum reduction in beneficial insects, cause a minimum of air pollution and be nonhazardous to higher animals.

RESEARCH APPROACHES:

A. Evaluate new insecticides in the laboratory and field for insect control.

B. Test different insecticide formulations, rates, and time of application using different types of ground and aerial equipment.

C. Evaluate systemic insecticides as soil and seed treatments.

D. Evaluate the effect of insecticides on beneficial insects and wildlife.

E. Determine insecticide residues in the plant and soil after application and in straw and grain at harvest.

POTENTIAL BENEFITS: Elimination or reduction of residue problems and reduced air, food, soil, and water pollution would be direct benefits. Safer and more effective insecticides would reduce residue hazards to health of man and animals and would lower cost of control.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
7	8

TITLE: Evaluation of harmful foreign insects. RPA 207-F.

SITUATION: Several of the insects most destructive to wheat and other small grains have been accidently introduced from foreign countries. Although Federal inspectors guard every sea and border port to apprehend pests, the increased world trade and travel makes it almost impossible to prevent additional accidental introductions. Research on wheat and other small grain insects is being conducted in some foreign countries under P.L. 480 programs and by various International Research Organizations. These projects have been especially effective in evaluating parasites and predators of some foreign insects. However, these research programs are confined to limited areas.

If more information on the biology and control of major wheat and other small grain insects and insect vectors of viruses which do not now occur in the United States could be obtained, we would be in a much better position to prevent introduction or if introduced the chances of eradication and/or prevention of spread would be enhanced. By studying these insects in their native habitat, information on parasites, predators, and diseases would be available so that these biological factors could be used against the pest without delay if and when it was introduced. Commodity-treatment research conducted with foreign insects would lead to more effective methods of preventing introductions.

OBJECTIVE: To investigate the biology, ecology, and control of major foreign insects and insect vectors of viruses and use this information to prevent introduction or, if accidently introduced, use information for eradication or prevention of spread.

RESEARCH APPROACHES:

A. Determine distribution, mating, feeding, migration, and preference for alternate host plants of major insects attacking wheat and small grains and insect vectors of viruses in foreign countries.

B. Screen U.S. varieties and World Collection for reaction to major foreign insects.

C. Identify and evaluate effectiveness of parasites, predators, and pathogens of foreign insects.

D. Develop effective commodity treatment methods for foreign insects.

POTENTIAL BENEFITS: Direct benefits would accrue from reduced possibility of insect introductions or, if introduced, minimized effects upon production of wheat and other small grains. Obtaining biological information on foreign insects and developing control methods prior to introduction of the insect could prevent serious losses. It is not possible to quantify the magnitude of the benefit of protection against foreign insects. However, devastating insects which do not now occur in the U.S. are known in other parts of the world.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	1

TITLE: Insect sterility, attractants, and other new approaches. RPA 207-G.

SITUATION: The use of insects for their own destruction by employing the sterility or other genetic principles, offers a new approach to insect control that has been demonstrated successfully for controlling the screwworm and certain tropical fruit flies. It has been shown that when sterile insects are released and compete with the normal insects for reproduction, the biotic potential of the natural population can be greatly reduced. Insects are attracted to various stimuli, including specific substances in host plants, to natural products such as sex attractants produced by insects themselves, and to light, sound, and other electromagnetic radiations. The use of chemosterilants in conjunction with attractants that will lure insects in large numbers has good possibilities for controlling some insects. The use of natural or synthetic hormones as a possible means for development of methods to interfere with or interrupt insect growth and reproduction offer excellent possibilities for control.

OBJECTIVE: To investigate methods of sterilizing insects; isolate attractants, hormones, or other biological active materials and use this information in developing control methods.

RESEARCH APPROACHES:

A. Conduct tests to determine if the major wheat and other small grains insects can be sterilized with radiation or chemosterilants and determine if the sterile male release technique can be used for area-wide control.

B. Conduct tests to determine if insects have dominant deficient genes that can be utilized as lethal factors or to reduce fecundity and mass release these types.

C. Isolate sex attractants from major wheat and other small grain insects and conduct laboratory and field tests on the feasibility of controlling these insects by the use of these or other attractants.

D. Evaluate light, sound, and other electramagnetic radiations as insect attractants.

E. Evaluate the effect of natural or synthetic hormones on the growth and reproduction of insects.

POTENTIAL BENEFITS: The cost of production could be reduced by reducing or eliminating the need for insecticides. Residue hazards and air, food, soil, and water pollution are continuing problems which could be alleviated. It might be possible to eradicate some insects by using these new approaches. If even one or two of the major insects could be eradicated or controlled on an area-wide basis, the benefit would far exceed the cost and, in addition,

the residue hazard would be reduced.

RESEARCH EFFORT:	TF RECOMMENDATION	
	1972	1977
	5	8

TITLE: Control of diseases through genetics and breeding. RPA 208-A.

SITUATION: The hazards and instability of production of wheat and other small grains are increased by disease. The first line of defense in the control for many diseases has been the development of varieties with specific resistance. However, those varieties usually remain resistant for only a few years when grown commercially because strains of the pathogen arise which are virulent on those varieties. Information on new sources of resistance, methods of breeding and producing resistant varieties are required, so that varieties with new sources of resistance can be produced more rapidly. A secondary defense involving tolerance or field resistance needs to be implemented.

OBJECTIVE: To identify new sources of resistance to pathogens. To implement methods for breeding and producing resistant varieties more rapidly, and so that they will also have field resistance or tolerance.

RESEARCH APPROACHES:

A. Identify new sources of resistance to various pathogens, not only in the small grains, but also in related species and genera.

B. Determine the mode of inheritance of resistance to pathogens.

C. Determine the mechanisms by which new virulent strains of pathogens arise.

D. Develop methods for breeding and producing resistant varieties more rapidly.

E. Use alternate host nurseries, in the case of the rusts, to provide a broader base of resistance.

F. Emphasize the search for minor or modifying genes for resistance.

G. Utilize massive screening techniques for resistance to non-specialized pathogens.

H. Study the factors causing yield depression by disease and search for genes which provide tolerance or general field resistance to the specialized pathogens.

POTENTIAL BENEFITS: The improvement in methods for breeding and producing resistant varieties should reduce the hazards of production, increase forage and seed yield, improve seed quality, and increase the number of resistant varieties available to be grown commercially. Diseases cause an estimated loss of 10 to 20% each year. At least one third of this loss might be saved through the use of improved resistant varieties.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
40	45

TITLE: Management practices in relation to disease incidence. RPA 208-B.

SITUATION: Management practices are being changed to increase production by intensifying farming practices, decreasing diversification, reducing crop rotations, increasing fertilization, increasing irrigation, changing plant morphology, and developing hybrids. Many root and foot rots, leaf blights and spots, and head blights have been partially controlled by the management practices which are now being changed. Pathogens which have not been important may become more prevalent and pathogenic, and pathogens which have been important may now become less important. Possible changes in disease incidence must be detected with the changes in management practices, and methods must be developed immediately to control those diseases.

OBJECTIVE: To identify changes in disease incidence associated with new management practices, and develop methods for controlling those diseases which become prevalent.

RESEARCH APPROACHES:

A. Identify pathogens associated with hosts grown under new management practices.

B. Determine changes in micro-environment and ecology resulting from changes in management practices and how these affect pathogens.

C. Develop methods for controlling diseases associated with new management practices.

D. Study disease escaping mechanisms such as early or late seeding, maturity, and other, in relation to new management practices.

POTENTIAL BENEFITS: The new methods of disease control that are developed will permit new management practices to be used which will increase the yield and quality of seed. Increases in production associated with the new management practices could be off-set by the increased incidence of diseases. However, some of the losses from diseases may be saved by new control practices implemented along with the new management practices.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
18	25

TITLE: Chemical control of diseases. RPA 208-C.

SITUATION: Pesticides have not been used extensively to control diseases of wheat and other small grain because methods for forecasting epidemics were inadequate, applications costs were high, increases in yield and quality were not satisfactory, and return per acre from the crop was low. However, new systemic fungicides have recently been developed which show promise of effective control for many smuts, rusts and other diseases. These fungicides are compatible with other pesticides, relatively inexpensive, easy to apply, non-phytotoxic, and show satisfactory increases in seed yield and quality. Systemic insecticides which control aphids and other vectors for cereal viruses have also been discovered.

OBJECTIVE: To develop methods for using pesticides to control diseases.

RESEARCH APPROACHES:

A. Determine the best methods, rates, and times of application of pesticides for disease control.

B. Determine phytotoxicity and compatibility of pesticides.

C. Study degradation of pesticides in soils and plants.

D. Evaluate effect of pesticides on yield and quality of both forage and seed.

E. Assist the agricultural chemical industry in the search for more suitable fungicidal materials.

POTENTIAL BENEFITS: The stability of yield and quality of seed and forage will be increased by controlling or reducing severity of certain diseases with pesticides. As a result, those factors which increase yield and quality can be given more emphasis in the breeding of new varieties and in developing management practices. By permitting more emphasis on yield and quality in breeding and management practices, higher yields of quality seed should be attained. Approximately 10% of the losses from disease may be saved by the use of pesticides.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
9	10

TITLE: Evaluation of hazardous foreign pathogens. RPA 208-D.

SITUATION: Many pathogens and strains of pathogens and insect vectors of viruses known to cause diseases of wheat and other small grains in foreign countries have not been identified in the United States. The reaction of U.S. germ plasm to some of these pathogens is not known.

OBJECTIVE: To determine the reaction of major U.S. varieties, advanced selections, early generation lines and other sources of germ plasm of wheat and other small grains to foreign pathogens and evaluate the potential damage they could cause if introduced into the United States.

RESEARCH APPROACHES:

A. Identify and classify pathogenic organisms to determine whether they are present in the U.S.

B. Screen U.S. varieties, advanced selections and other sources of germ plasm for reaction to foreign pathogens in areas where diseases are found.

C. Study the development and methods of control of diseases potentially dangerous to the U.S. in areas where they occur.

D. Initiate breeding programs in cooperation with foreign scientists to develop resistant lines for U.S. areas where disease is most likely to survive if introduced.

E. Conduct international small grain disease nurseries and participate in International Biological Program in order to obtain maximum effectiveness of international programs.

POTENTIAL BENEFITS: This research would minimize the effect upon U.S. wheat and other small grain production if foreign pathogens are introduced. Damage to the U.S. crop is only potential, but dangerous pathogens and virulent strains of pathogens now present or likely to be found in foreign countries could cause devastating losses to U.S. wheat and other small grain crops.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
1	1

TITLE: Epidemiology of small grain diseases. RPA 208-E.

SITUATION: A large number of fungus, bacterial and virus pathogens, and strains of these pathogens attack wheat and other small grains. Numerous factors affect the initiation, development, severity, and movement of epidemics. It is important to evaluate these factors in order to develop efficient control systems.

OBJECTIVE: To identify and evaluate the factors controlling the initiation, development, and movement of disease epidemics.

RESEARCH APPROACHES:

A. Identify the host range and life cycle of pathogens virulent on wheat and other small grains.

B. Identify and evaluate environmental, ecological, biological, and other factors affecting the sources of inoculum, initiation, rate of development, and movement of epidemics.

C. Study effect of various specific or non-specific host genes or resistant factors on development and progress of epidemics.

POTENTIAL BENEFITS: The benefits from this activity are related directly to the control of epidemics. Research in this area would be in direct support of control methods devised in Titles 208-A and 208-C. The magnitude of potential benefits cannot be quantified specifically and in general is included in Titles 208-A and 208-C.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
4	5

TITLE: Biology, physiology, and nutrition of diseases. RPA 208-F.

SITUATION: Many organisms are known to be pathogenic on wheat and other small grains, and other organisms may become pathogenic as a result of the new management practices and changes in host or pathogen characteristics. To develop methodsand controlling those diseases, their biological, physiological, and nutritional characteristics must be determined.

OBJECTIVE: To develop new methods for controlling diseases by studying their biology, physiology, and nutrition.

RESEARCH APPROACHES:

A. Identify and classify pathogenic organisms associated with diseases of wheat and other small grains.

B. Determine the biological, physiological, and nutritional characteristics of these diseases.

C. Develop new methods and concepts for controlling diseases.

POTENTIAL BENEFITS: The methods of disease control which evolve from this activity should help in stabilizing production and assure continued increases in yield and quality from new management practices and plant characteristics. The quantification has been included in 208-A, 208-B and 208-C.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
16	20

TITLE: Host-pathogen-vector relationships in disease development. RPA 208-G.

SITUATION: A disease is the result of the interaction of host and pathogen. For some diseases insect vectors or alternate host are also involved. Much information on relationships of those organisms has been obtained from studies of diseases of wheat and other small grains. The hosts, pathogens, and vectors are well adapted for these studies, and individuals and techniques for conducting such studies are available. The information which can be obtained from these studies is in direct support of the work outlined in 208-A.

OBJECTIVE: To develop a better understanding of host-pathogen-vector relationships which aid in developing more reliable and adequate methods for controlling specific diseases.

RESEARCH APPROACHES:

A. Near-isogenic host lines, and host varieties with known disease resistance genes, will be developed or identified.

B. Cultures or strains of the pathogens, vectors, and alternate hosts with specific characteristics willbe obtained and maintained.

C. Genetic, physiologic, morphologic, histologic, and serologic relationships within and between the organisms and their hosts involved in producing specific diseases will be isolated and studied.

D. Make a world-wide search for host-pathogen systems which inhibit disease development.

E. Develop methods of breeding and management so that these systems may be used more effectively in disease control.

POTENTIAL BENEFITS: The information from this activity will be utilized in developing techniques for breeding resistant varieties and methods for controlling diseases, which will stabilize production by reducing losses from diseases. The information will be applicable to diseases of other crops and will, therefore, stabilize the production of those crops. The magnitude of the benefits to be derived from this activity cannot be specified, since they will come from the improvement of varieties and more reliable methods for controlling diseases, which has already been emphasized in 208-A.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
13	16

TITLE: Biology, physiology, and nutrition of weeds. RPA 209-A.

SITUATION: Most species of weeds survive, flourish, and multiply under a variety of conditions -- both favorable and unfavorable to growth of wheat and other small grains. Although 2,4-D effectively controls many annual broadleaf weeds, other weeds such as wild oats, brome grasses, foxtails, wild buckwheat, field bindweed, wild garlic, quackgrass, and Canada thistle are controlled only marginally by current techniques. These and other resistant weeds are increasing as problems in small grain culture. The ultimate weed control practice is one that will prevent weeds from forming seeds, prevent seeds from germinating, or induce germination of all seed and other propagules in the soil. Limited research indicates that certain compounds affect germination when applied to weed seed on growing plants, or to weed seed and other propagules in soil. Other research indicates the possibility of influencing germination of weed seed by cultural techniques. Weeds also vary in their susceptibility to control by herbicides and cultural practices in accordance with specific differences in their biology. Relatively little is known about the physiology, nutrition, and ecology of weeds in relation to growth and reproduction in competition with small grains. More effective weed control could be achieved with better information on the biology of these weeds.

OBJECTIVE: To determine if there are specific weaknesses in certain weeds, or ways of preventing their propagation that will lead to more effective control measures.

RESEARCH APPROACHES: (To be coordinated with RPA 307-E, Crop Physiology)

A. Study seed germination, seed production, and growth of certain weeds in competition with small grains.

B. Examine the effects of growth regulators and other chemicals on weed seed and other propagules when these compounds are applied to plants, and when incorporated in the soil.

C. Compare the physiology, ecology, and nutritional requirements of problem weeds with those of small grains to discover differences that can be used to favor the crops in competitive situations, and to develop chemical and nonchemical treatments for selective control of the weeds.

POTENTIAL BENEFITS: The development of practical methods of controlling or eradicating problem weeds in fields of small grain through RPAs 209-B and 209-C would be enhanced by this research. Ultimately, increased yields of small grain, lower costs of production, and substantial improvement in quality would be the basic benefits. Costs of controlling weeds and losses of weeds in small grains could be cut almost in half.

RESEARCH EFFORT:	TF RECOMMENDATION	
	1972	1977
	7	13

TITLE: Control of weeds with herbicides. RPA 209-B.

SITUATION: Herbicides registered for use in small grains have been of tremendous value to producers. Many herbicides, however, are not registered for use in small grain. Detailed research involving registered herbicides alone, and in combinations, is needed to find better control methods for specific weeds. In addition, new herbicides, and other herbicides not registered for use in small grain, should be evaluated for control of specific problem weeds in small grain. Many of the new and unregistered materials have not been developed for practical use because of small market potential in crops other than small grains. This research should result in a much wider spectrum of chemicals for chemical weed control. Current uses of herbicides, even though they reduce losses caused by weeds, sometimes reduce yields if comparisons are made with the yields from weed-free fields. Some herbicides that could be used in small grains would present hazards to other crops by drift and by residues in the soil.

OBJECTIVES: To develop better chemical weed control treatments by studying combinations of currently registered herbicides for specific weed problems in small grains and to determine if unregistered herbicides, alone or in combination, have potential for these specific weed problems. Reduce herbicide injury to the crops through a better understanding of the mechanisms by which herbicides act. Develop techniques of using herbicides that prevent or reduce adverse effects on other crops through drift or residual toxicity in the soil.

RESEARCH APPROACHES: (To be coordinated with RPA 308)

A. A wide variety of presently available chemicals and chemical combinations will be evaluated for toxicity to specific weeds growing in grains. These would include growth regulators, growth retardants, defoliants, and chemicals cleared for use on other crops.

B. Determine the most effective stage of growth for chemical application to eliminate weed plants or to prevent production of viable seed. (This work would be coordinated with 209-A)

C. Conduct research on methods of applying herbicides, on mechanisms of herbicide action, and on timing of herbicide applications to reduce the incidence of crop damage.

D. Conduct research to develop cultural techniques for speeding the detoxification of herbicide residues in the soil after a crop is harvested.

POTENTIAL BENEFITS: Increased grain yields by reducing weed competition, cleaner grain at the elevator, and dryer grain with better keeping quality are some of the direct benefits.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	8

TITLE: Management and cultural practices for weed control. RPA 209-C.

SITUATION: Cultural practices, such as seedbed preparation, choice of crop variety, disposition of litter after harvest, and control of other pests, acutely influence the ability of crops to compete with weeds, and usually influence the effectiveness of weed control with herbicides. Where management practices are selected for complementary action with herbicide treatments, the crops are better able to compete; and propagation of weeds through seed, and other propagules, is minimized. Currently we have little quantitative data to help us determine the best choice of cultural practices for combining with specific systems of herbicide usage.

OBJECTIVE: To examine various management practices in small grains that will lead to vigorous crop growth in relation to weed germination and development.

RESEARCH APPROACHES: (To be coordinated with RPA 207, 208, 307, and 308)

A. Study seedlingvigor and canopy of small grain strains and varieties for their ability to compete with weeds, and for special tolerance to weed control treatments.

B. Examine techniques of seedbed preparation that facilitate rapid crop germination and slow germination of weed seed.

C. Study soil characteristics and systems of adding fertilizers that may affect weed growth and development.

D. Study the potential of rotation systems where other crops on a farm can be used in a particular field for the control of a particular weed with a particular chemical.

E. Exploit the results of research described in 209-A and 209-B to strengthen the management research described above.

POTENTIAL BENEFITS: Increased grain yields, less contamination of grain with weed seed and weed trash, and a decrease in the weed population on farm land would be direct benefits.

RESEARCH EFFORT	TF RECOMMENDATION	
	1972	1977
	5	7

RESEARCH PROBLEM AREAS FOR PRODUCTION OF CROPS

TITLE: Management practices to improve production efficiency. RPA 307-A.

SITUATION: Maximum production of small grain results from combining the optimum plant density, appropriate plant spacing, moisture supply and fertilization for each variety. The influences of these factors need to be determined for diverse types of soil, levels of rainfall, and temperatures to establish principles for managing each variety. When radically new plant types are developed, optimum levels of each of the management factors need to be redetermined. Moisture supply is a serious limiting factor in many of the small grain producing areas. Genotypes that use water more efficiently, new planting and spacing techniques, and new irrigation practices, where water is available, offer means of improving production. Soil management techniques to deal with excess acidity or alkalinity, that limits yields in some areas, often influence or modify other factors such as elemental deficiencies or toxicities and buildup of soilborne diseases. New materials for seed coatings and growth regulation are continually becoming available. New techniques for using these small grains may provide solutions for a wide range of problems. Small grains are grown for grazing, particularly winter types in the Southern states. For this purpose, varieties are needed that have a growth habit which provides large amounts of forage during late fall, winter or spring and a growing period that permits use of the land for other crops during the remainder of the year.

OBJECTIVE: To determine the optimum plant density, kinds and rates of fertilizers, irrigation practices, and soil management practices for specific varieties and environments; to explore the value of new materials for seed coating and regulating growth in production practices, and to manage small grains for grazing to produce high yields of quality forage and to enable an annual multiple cropping sequence.

RESEARCH APPROACHES:

A. Evaluate planting methods, plant density, and plant spacing for optimum production with existing and new varieties.

B. Determine varietal interaction with the kinds and amounts of fertilizer elements.

C. Determine the optimum timing and amount of water applications to small grains in irrigated areas.

D. Evaluate varieties and to develop practices under dryland conditions for higher moisture use efficiency and conservation.

E. Develop soil management practices to overcome problems associated with soil acidity or alkalinity and the buildup of soilborne diseases.

F. Search for ways of using new materials for seed coatings and growth regulation to solve production problems or to augment productivity.

G. Explore winter growth habit and time of planting of varieties for high quality production through grazing and develop year-round cropping systems that provide a high total production per acre per year.

POTENTIAL BENEFITS: All of the approaches offer higher yields in numerous ways. The sum of yield improvements for the nation through the research proposed would be significant as well as greater stability of production. It could easily be 1, and might be 5 bushels per acre nationally. Each added bushel per acre would be worth an appropriate value per bushel multiplied by 100,000,000.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
36	40

TITLE: Collection and maintenance of world germ plasm stocks for use in breeding. RPA 307-B.

SITUATION: The success of the small grain breeding work in the United States in producing improved varieties is due to (1) the introduction of varieties and species from the Old World (small grains are not endemic to the New World) and (2) the use of hybridization to breed superior varieties by combining favorable genes present in world small grain collections. This is a progressive process as new improvements are added constantly. The growth rate of the USDA World Collection is about 4 percent per year, and at present the total number of entries for wheat is 18,500; barley, 10,000; oats, 9,000 and rye, 300. In addition, there are the noncultivated or wild types which include 800 wheats, 1,500 barleys, and 2,900 oats - for a grant total of 43,000.

The World Collections are supplemented by breeding stocks made up of lines which combine many desirable genes, and genetic stocks with marker genes, translocations, and variations in chromosome number for use in basic genetic studies.

Working stocks of the World Collection are housed in air conditioned rooms at Beltsville, Maryland, and the viability and seed supply are maintained by periodically growing each entry at Mesa, Arizona, or Aberdeen, Idaho. Long-time storage is provided at nearly optimum conditions in the National Seed Storage Laboratory, Ft. Collins, Colorado.

Seed is distributed world-wide upon request to bona fide research workers. Information obtained on the collections by scientists is processed at Beltsville and made available to interested workers. The average annual distribution of seed to domestic workers amounts to about 46,000 entries to 75 workers in 30 states. The foreign distribution amounts to about 33,000 entries to 80 workers in 36 countries.

OBJECTIVE: To maintain a supply of viable seed of the World Collections of wheat, barley, oats, rye and buckwheat, and of breeding and genetic stocks; and to distribute seed and information obtained on the collections to all interested breeders and research workers.

RESEARCH APPROACHES:

A. Organize and instruct exploration parties to discover, collect, import, classify, and describe new germ plasm having potential usefulness in breeding work. Also, through correspondence, visitation, reciprocal exchanges and by other means, obtain potentially useful germ plasm from foreign and domestic workers to augment the gene pools represented by the USDA World Collection.

B. Organize and perfect the mechanics of receiving, increasing, and preserving new entries, and develop an effective and efficient record system adaptable to data processing for identifying each entry, including ways for the addition and retrieval of data on each entry.

C. Deposit a viable sample of each entry, properly identified and annotated, in the National Seed Storage Laboratory at Ft Collins, Colorado, as an added precaution against loss and for long-time viability.

D. Accumulate, tabulate, and analyze data obtained by cooperators growing the collections in order to find genotypes useful in solving new problems and to find the frequency of various genes and/or gene combinations.

POTENTIAL BENEFITS: The World Collections are gene pools representing the survivors of two processes - mutation and natural selections. It is estimated that the USDA Collections hold about 90 percent of the world's supply of different genes, and, therefore, a large proportion of the improvements made by man must, in the end, be traceable to genes in these pools. Since each plant is the summation of the action of its genes, and since World Collections are the sum of all genes, then the magnitude of the benefits must be equivalent to the total value of the crops.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	6

TITLE: Utilization of heterosis. RPA 307-C.

SITUATION: Recent scientific discoveries indicate that utilization of heterosis in the small grains is very likely commercially feasible. A hybrid barley has been released, hybrid wheat appears close at hand and the possibilities in oats are being investigated. Research efforts have been rather limited to the present time, but many factors need to be investigated before hybrids are available on a large scale to American farmers. Some of the unknown factors are involved with genetics of male sterility and restoration and a large amount of investigation needs to be made on field production problems. In addition to the breeding and production problems, there are many areas of cereal chemistry that need to be investigated fully to insure adequate quality factors.

OBJECTIVE: To utilize heterosis in small grains and to insure adequate quality characteristics.

RESEARCH APPROACHES:

A. Study possible sterile and restorer systems, including cytoplasmic, genetic (including tertiary trisomic) sterility; seek new, alternative working forms of sterility and restorers. Determine the inheritance and response to environment characteristics of sterile and restorer lines.

B. Study environmental, morphological and physiological factors that influence field pollination. Screen world collections for uniquely suitable genotypes. Through breeding transfer genes favorable to pollen dispersal and reception.

C. Determine the influence of the heterozygats condition on milling baking, malting, brewing and other industrial processing qualities, as well as its effect upon morphological traits and disease and insect resistance.

D. Investigate management and environmental factors that foster maximum yields of hybrids.

E. Broaden a program of test crosses of genotypes to find parental combinations that provide hybrids having maximum yield, quality and field performance characteristics.

POTENTIAL BENEFITS: Information to date indicates that utilization of hybrids in barley and wheat will allow yield increases on the same order as American farmers have obtained with hybrid corn and sorghum - or about 20 percent. Utilization of heterosis also offers a possibility of developing unique types for special end uses. Transfer of disease and insect resistance also promises to be easier with hybrids than in the case with varieties.

RESEARCH EFFORT:	TF RECOMMENDATION	
	1972	1977
	20	20

TITLE: Basic genetic, cytogenetic, and mutation approaches to breeding. RPA 307-D.

SITUATION: Greater efficiency in accomplishing genetic gains is the key to more adequate food production in the future. As research and breeding methods in small grains become more sophisticated, additional basic genetic and cytogenetic information must be made available. An example of this need is presented by hybrid barley whose present system operates on a cytological abberation trisomy. A good deal of the present genetic information in wheat originates with aneuploid materials. A closer relationship must be established between basic genetic studies and biochemical investigations based on the chemical products of genetic information to increase not only quantity but quality in small grain production.

The genes or cytoplasm necessary for improving varieties or hybrids often do not exist in cultivated species. For this reason it is necessary to transfer genes or cytoplasm from related species or genera. Excellent disease and insect resistance have been transferred in this manner, or a new species such as Triticale has been built. Great difficulties are encountered, however, in making wide crosses, first in making the cross itself and second in circumventing the sterility that occurs in the early generations following a cross. An urgent current need is to transfer the cross-pollination habits found in the wild relatives to wheat and barley to help the hybrid program in these crops. Similarly, the greater winterhardiness in wild relatives needs to be transferred, especially for oats and barley.

OBJECTIVE: To further expand the genetic and cytogenetic information in wheat, barley, and other small grains, to relate this information to plant improvement and to discover principles and techniques that will enhance the successful use of species and generic crosses in cereal grain breeding.

RESEARCH APPROACHES:

A. Utilizing aneuploids, substitution lines, isogenic lines and other genetic systems which are or may become available, relate genetic information to end product formation through an interrelation of genetic and biochemical investigations.

B. Using chromosome systems as listed in Approach A, determine the inheritance and relative importance of components of quantitative characters such as yield and quality.

C. Investigate the potential of genetic change and production of new and diverse germ plasm through radiation techniques. Studies should be conducted on the amount of genetic change produced in small grains by high energy waste products which are likely to become more abundant in a nuclear society.

D. Measure the relatedness between cultivated small grains and their wild relatives by DNA hybridization tests. This information can serve as guidance information for selecting crosses having the best chance to succeed.

E. Further perfect embryo and tissue culture techniques, procedures, and media to insure greater success in difficult crosses.

F. Develop the tissue culture hybridization procedure in order to make wider crosses than now possible. This could provide a means for getting completely new plants (crops) for agriculture-crops that never existed before. Triticale can be considered as a prototype of this class of plants.

G. Adapt or modify the technique now used for species and generic crosses to unilateral cases where the cytoplasm of the wild species is required, as illustrated by cytoplasmic male sterility. The studies should also encompass better ways to search for restorer genes.

POTENTIAL BENEFITS: These may be enumerated as follows: Reduction of losses due to diseases and insects; increased yields due to hybrids based on cytoplasmic male sterility; increased food and feed value; breeding completely new crops for American agriculture; improved relation of basic genetic and cytogenetic information to breeding programs; production of plant types with higher yield and nutritional levels; greater understanding of components of complex characters; and production of more diverse germ plasm for future use.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
44	58

TITLE: Crop physiology and ecology to improve productivity and facilitate variety development. RPA 307-E.

SITUATION: The improvement of the small grains through breeding has been successful, in spite of a paucity of information about many of the basic growth processes, morphological attributes and genotype-environment inter-

actions affecting plant performance. The rate of improvement of crop performance for the future will depend more upon the sophisticated use of genetics and a better understanding of the attributes of plant performance. There is a need to identify the components influencing high biological efficiency, the magnitude of their influence, and their mode of action so that a new approach can be made to maximum yields and quality of the cereal grains.

OBJECTIVE: To understand the basic biological processes, morphological traits, response characteristics, and genotype-environment interactions in the small grains to the end that this knowledge and these genetic materials may be used to maximize the quantity and quality aspects of plant performance.

RESEARCH APPROACHES:

A. Investigate the temperature-related phenomena of winterhardiness, drouth reaction and heat stress to discover why plants survive cold, drouth and heat.

B. Study photosynthesis, photoperiodism and light sensitivity, phytochrome, respiration, translocation, enzymatic activities and storage processes to determine the factors influencing the efficiency and quantity of plant production. Involved are studies on light, CO_2, water and air movement, plant morphology and spatial arrangement, and the relative efficiency of a plant's physiological processes that lead to total growth and storage products.

C. Study population dynamics to determine how competition, density, spatial organization, plant architecture related to the role of leaves, roots and tillering, and genotype-environment interactions affect maximum yields, quality, disease and insect incidence in the cereals. Investigate the performance and feasibility of multiple genotype varieties.

D. Study the goal of maximum yield itself through a comprehensive partitioning analysis of the life cycle of efficient cereal genotypes and the environments in which they show the capability of superior production. Attempt to isolate and identify the responsible factors or processes and synthesize new genetic combinations for increased yield and improved quality.

E. Study the mineral nutrition of genotypes to determine the variation and range of need and mode and efficiency of utilization by plants.

POTENTIAL BENEFITS: These research approaches will provide the information and genetic materials that, coupled with cultural modification of plant environment, can lead to maximum yields and quality of cereal products. The results will be useful to both pure line and

hybrid varieties. Theory suggests that the present yields of hybrid cereals eventually can be attained in improved pure line varieties -- this gap now is estimated at 20 percent. Progress in these research areas will raise the present yield "ceiling" for both hybrid and pure line varieties.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
40	54

TITLE: Mechanization of production. RPA 308.

SITUATION: The production of small grain crops is nearly 100% mechanized. However, considerable inefficiency and loss occurs because many machines lack flexibility and, hence, are not ideally adapted to the requirements of particular crop varieties, soil situations and labor supplies. In some seasons wet weather at harvest results in high-moisture grain that must be dried; safer, more efficient means are desired to handle and dry the grain and preserve its quality. The stresses of moisture and temperature extremes on plants are enormous. Research through engineering adaptations to alleviate some of these stresses may involve better seedbed preparation, precision sowing of seed, moisture conservation, better weed controls, residue disposal, pesticide applications, drying of grain, and reduction of losses of several kinds. In some areas noxious animals cause extensive damage.

OBJECTIVE: To improve efficiency of mechanical operations for better small grain production, to obtain higher quality, to minimize environmental stresses on the crops, and reduce losses.

RESEARCH APPROACHES:

A. Conduct independent and cooperative studies with crop, soil and industry specialists to modify or develop mechanical devices to obtain improved results.

B. Through the application of principles of physics and engineering devise new systems to grow crops more efficiently.

C. Eliminate or reduce harmful insects, noxious birds, rodents, and pathogens by traps, lures, anti-agents and by other devices.

D. Devise altered production schemes to conserve power, make more efficient use of labor, reduce loss, and enhance quality in the growing, harvesting and marketing of the small grain crops.

POTENTIAL BENEFITS: Direct benefits are reduced cost of production and increased value of crops harvested. Perhaps one bushel per acre could be added nationally by this research or about 100,000,000 bushels of grain.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
4	6

TITLE: Systems analysis for production and marketing of small grains and buckwheat. RPA 309.

SITUATION: Grain producers must choose among many alternatives for selection of varieties, planting times, row spacing, plant populations, size and capacity of machinery, time and amount of fertilizer, irrigation, and pest control practices. Selection of alternatives to optimize the use of land, labor, capital, and machine capacity in farm production and marketing must take into account relative market prices of grains of different qualities and locations, changing production techniques and farm program adjustments. Changes in price differentials over time will depend upon and reflect shifts within and between domestic and foreign markets, shifts in market structure as alternative combinations of marketing resources are adopted and variations in market imperfections that affect pricing efficiency. Mathematical models are needed to simulate the variables and alternatives in the production and marketing system in order to compare the profitability of various alternatives.

OBJECTIVE: To combine that set of production and marketing practices, capital investments, and labor availability that will optimize income from small grain production and marketing on individual farms.

RESEARCH APPROACHES:

A. Adapt or develop and use mathematical models for simulating small grain production and marketing systems to identify factors requiring additional research.

B. Test hypothetical systems of utilizing all known resources to produce maximum yields. Simulated differences in varieties, nutrients, water, herbicides, and other elements of management practices will be compared to determine the most productive and economical combinations.

C. Simulate and test alternative marketing arrangements to discover efficient practices and measure the impact of proposed changes on producer income.

POTENTIAL BENEFITS: Reduced production and marketing costs seem assured but insufficient data are available to estimate the potential benefits. Systems analysis for wheat and other small grains should be a part of more broadly based analyses for the entire commodity systems including several crops and livestock. The larger the number of end uses of an enterprise, the greater are potential benefits from systems analysis. Benefits will be realized in many areas due to greater production and marketing efficiency.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
7	15

TITLE: Improved milling, baking, processing and nutritional quality in wheat, buckwheat, rye and related grains. RPA 405-A.

SITUATION: Quality in wheat is a complex of factors including genetic, environmental, biochemical, and those imposed by the art of processing. Because of disease problems the useful life of varieties frequently is only about five years, consequently there must be continuous, active progress in plant breeding. Since many factors must be combined in new varieties, a wide range of parental material and large numbers of plant selections are used. This work creates wheats having a wide range of flour properties. By determining the milling, baking, and processing quality of early generation materials when only small quantities of grain are available, selection of new varieties having desirable agronomic and industrial properties is facilitated. More elaborate quality evaluations must be made on succeeding generations of promising selections prior to release for commercial use.

The biochemical basis for commercial and nutritional quality differs in kind and degree from product to product. However, there is a paucity of information concerning biochemical factors, basic processing mechanisms, and clearly deliniated definitions for quality. Only scant information is available concerning fundamental physical and chemical changes which occur during mixing and baking; moreover, the chemical composition of the flour may contribute to these modifications which result in variations in quality. Because the milling, baking, and processing industries are highly automated, uniformity in quality of their raw materials is essential to efficient operation. Consequently, there is a need to define quality in meaningful chemical and physical terms and a need to develop more precise tests to measure quality and to translate this knowledge into industrial raw and processed products. When these objectives are achieved, growers, processors and consumers alike will benefit.

Quality problems in each of the five major classes of wheat (durum, hard red spring, hard red winter, soft red winter, and white) relate to criteria associated with their end use. There are many similar laboratory techniques employed in evaluating quality characteristics; chemical analyses of fat, mineral, moisture, protein content and composition as well as milling techniques appear similar. However, the processing and evaluation of the granular product, flour, farina and semolina, varies with end-product desired. For example, chemically leavened pastry goods require a finely granulated flour having low protein, mellow gluten, and a low water absorption; these requirements are met most appropriately by certain of the white and soft red winter wheats. Contrariwise, yeast leavened, hearth breads require flour having high protein content, strong gluten, and a high water absorption; these properties are found in hard red spring and certain of the hard red winter wheats. Obviously, unique wheat breeding and laboratory evaluation programs are required to meet these needs.

Similar situations exist for other small grains such as rye, buckwheat and triticale which are or may be processed by the milling industry.

OBJECTIVE: To improve the factors in wheat contributing to more efficient and effective milling, to improve flour and semolina processing and nutritive properties, to investigate and account for the basic factors of quality, and to apply this knowledge to wheat improvement programs and commercial and public needs.

RESEARCH APPROACHES: Answers to these objectives lie in a multidiscipline research approach.

A. Identify genotypes containing significant chemical constituents in higher or lower than normal concentrations and use such genotypes to breed agronomically superior varieties with superior composition.

B. Explore the feasibility of creating hybrids and synthetic species having improved agronomic, chemical and nutritive properties.

C. Determine the significance of environmental factors during crop production on the levels of chemical constituents of special significance in processing quality, consumer acceptability, and animal and human nutrition.

D. Apply currently reliable milling, baking, and other quality tests to new selections under study by wheat breeders at all practical levels of development.

E. Adapt or develop quality tests to determine the suitability of wheat for domestic and foreign wheat foods.

F. Study fundamental factors responsible for differences in wheat quality with the goal of improving the efficiency of D.

G. Identify and determine mode of action of flour component(s) contributing to mechanisms, and relating of qualitative and/or quantitative differences in components to variety, environment, and treatment.

H. Devise and develop wheat and flour tests for more precise evaluation of breeding lines, with possible adaptation to early generation lines.

I. Cooperate with food and feed industry to identify biochemical and physical factors which affect new technological developments.

POTENTIAL BENEFITS: Uniformity at high quality levels among all varieties in milling and baking potential will facilitate marketing and utilization of wheat and help stabilize processing operations with resultant decrease in waste. Information from research should clarify functions, processes, and effects, thus defining quality and facilitating communication between segments of the industry. Higher protein in bread-type wheats and better balance of

amino acids would improve the nutritional value.New varieties must have milling and baking quality equal to, or better than, those presently grown in order to maintain competitive markets especially since a major portion of the crop must be exported. The dollar value of a change in wheat quality is impossible to assess, but a range of a few cents per bushel in the market price has a major impact on the agricultural economy.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
25	29

TITLE: Production of barley varieties and hybrids with improved quality for malting, pearling and feed. RPA 405-B.

SITUATION: Malting barley is a specialty crop used for human consumption. Malting barley producing areas are clearly defined and these areas have demonstrated their ability to consistently produce the quality barley needed by industry. Only certain varieties of barley are considered acceptable for malting and brewing. The determination of acceptability depends on physical, chemical and flavor characteristics. There is an anticipated substantial increase in malt usage in the next twenty years because of population trends. It will be necessary to increase processing efficiency of barley varieties as well as grain yields to meet the increased demand for malting barley. Presently acceptable malting varieties have improved enzyme activity and are higher in extractable materials than older malting varieties. Enzyme activity and the amount of extractable materials as well as other quality characteristics are genetically controlled. Further advancements in quality are possible through expanded efforts in breeding program studies of the physiology and biochemistry of the malting process and improvement of analytical procedures. Present breeding programs are submitting increasing numbers of experimental selections for quality evaluation. In addition to the selections from conventional breeding programs the advent of hybrid barley is expected to require evaluation of an almost infinite number of hybrids. Resources available for the identification of varieties and hybrids with superior malting quality and to conduct needed basic research of the malting process are inadequate.

Little information is available regarding the extent to which the processing efficiency of barley for pearling can be improved. There is a paucity of information with respect to the improvement of the nutritional value of barley. The increased use of barley for pearling and the widespread use of barley for feeding may demand that quality research be expanded to include these areas.

OBJECTIVE: To develop varieties with improved processing efficiency including further increases in extract, improved modification; the identification of biochemical factors contributing to malting quality including the identification of enzymes; improved analytical procedures especially for modification; to develop varieties with improved processing efficiency with regard to pearling; to develop feed barleys with improved nutritional value.

RESEARCH APPROACHES:

A. Identification of genotypes that possess the optimum balance of malting quality factors.

B. Determination of the range of genetic variability that exists for malting quality factors in varieties and hybrids.

C. Identification of biochemical factors and physiological processes contributing to malting quality.

D. Devise improved methods of analytical procedures for the determination of malting quality.

E. Define quality factors contributing to pearling efficiency.

F. Develop information regarding the nutritive value of barley including the range of genetic variability that exists with respect to total protein content and amino acid spectrum.

POTENTIAL BENEFITS: Varieties with improved processing efficiency can result in major savings annually to the processor and producer income from quality premiums. Varieties with improved nutritional value could result in increased returns for the producers and feeders.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
12	14

TITLE: Production of oats with improved quality for feed and food. RPA 405-C.

SITUATION: Quality problems in oats relate to oil content, protein content, amino acids, fatty acids and favor stability. Progress in producing oats with increased processing and product quality is limited by lack of knowledge as to causes of poor quality or the identity of significant constituents, particularly fatty acids. Analytical methodology in some instances is inadequate to support a breeding program.

The discovery of high protein in wild oats obtained from Israel offers the possibility of substantially increasing the nutritive value of cultivated oats. The transfer of genes for high protein from wild oats to cultivated oats will require a significant increase in present research resources.

OBJECTIVE: To develop varieties or practices to produce oats of improved processing quality, nutritive value and flavor stability; to increase protein quantity at the expense of carbohydrates; and to develop suitable techniques for measurement of chemical constituents (for example: saponins) or other factors which may be critical in processing, storage and use of oat products.

RESEARCH APPROACHES:

A. Transfer the high protein from wild oats to cultivated oats through plant breeding.

B. Identify genotypes containing significant chemical constituents in higher or lower than normal concentrations and use such genotypes to breed agronomically superior varieties with superior composition.

C. Determine the significance of environmental factors during crop production on levels of chemical constituents of special significance in processing quality, consumer acceptability, nutritional quality and flavor stability.

D. Devise new or modified analytical techniques appropriate to support Approaches A and B.

POTENTIAL BENEFITS: An increased supply of highly nutritious foods is the main benefit. This would come through improved protein balance, improved flavor and storage-ability along with savings in processing costs.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	8

RESEARCH PROBLEM AREAS FOR BETTER UTILIZATION OF CROPS

TITLE: Improved baked goods through process modification. RPA 406-A.

SITUATION: About 40% of bread and rolls in the U.S. is made by continuous-mix methods. Similarly high figures are found for other products, especially cakes. Rising labor and production costs press to force these figures still higher but many companies resist such a high degree of automation from reluctance to sacrifice product quality. Inability to compensate adequately for non-uniformities in flour, the baker's major and most variable ingredient, and its behavior in rigidly mechanical systems, for example, cause variations in bread and cake texture and crumb structure that often affect sales adversely. Flavor produced in bread products by the obligate abbreviated fermentation procedures in continuous-mix processes also is usually greatly reduced and less desirable than with conventional methods. Industry has modified procedures several times in recent years in efforts to overcome their faults with continuous-mix methods without satisfactory solution by empirical approaches. Until greater understanding of the functional properties of flavor and of the mechanisms of flavor development from fermentation and crust browning can be developed, the full benefit to industry and consumer of continuous-mix baking will be denied.

OBJECTIVE: To develop information to help the baking industry convert completely to cost-saving continuous-mix or similar operations while maintaining product texture, volume, and flavor equivalent to those from conventional methods.

RESEARCH APPROACHES:

A. Identify specific features of composition and specific properties of particular flour components responsible for variations in volume, crumb structure, and other physical properties of breads and other products during continuous-mix and conventional processing.

B. Devise rapid and reliable test methods to control such processing variables as mixer speed, oxidation treatment, and dough or batter throughput to obtain uniformly high quality continuous-mix products from differing flours.

C. Identify components, and their precursors, of freshly baked bread responsible for its popular aroma and taste and develop methods to enhance and stabilize them.

D. Develop modifications of continuous-mix methods, ingredients, or equipment to produce optimum amounts of desirable aroma- and taste-producing components in continuous-mix bread products.

POTENTIAL BENEFITS: Lower cost of producing bread, rolls, and other bakery products equal or better in quality than those made by conventional methods is the main benefit. Current total of bread and rolls produced by conventional sponge-and-dough methods is about 8.65 billion lb. An estimated savings in manufacturing cost of 0.61 per lb. would be expected by converting to continuous-mix methods. The improved quality of present continuous-mix products and benefits for cake, cookie, and cracker products would be additional benefits.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
16	19

TITLE: New and improved frozen dough products. RPA 406-B.

SITUATION: Recent wide fluctuations in retail sales of frozen bread and roll doughs reflect both the incipient strong demand for such products and undependable performance at time of use. The flavor appeal of the freshly home-baked products is very strong, but it is offset by deficiency in several quality factors of the products. The primary problem is inadequate stability of yeast activity during storage and retail distribution. Fermentation necessary for full development of flavor and best crumb grain and texture conflicts with retention of yeast activity. Operators must therefore freeze essentially unfermented doughs to attain minimum storage stability for successful distribution. Frozen doughs, especially the small pieces for rolls, are also very sensitive to thawing-refreezing and to even moderate storage temperature variations.

OBJECTIVE: To devise methods and formula changes for increasing to 100 days of storage the reliable baking performance of conventional frozen doughs and to develop new types of products, such as sour French doughs.

RESEARCH APPROACHES:

A. Determine differential effects of ingredient and production variables on reproductive (budding) and fermentative (gas producing) activities of yeast and work out optimal balances of such factors.

B. Determine effects of yeast strain, culture conditions, bacterial contamination, accumulation of selected metabolites, and related factors on yeast performance and determine conditions necessary for stable, ready-proofed frozen doughs.

C. Determine the nature of the microflora and the limiting conditions necessary for successful production of sour breads and develop methods for producing frozen dough versions on a nationwide basis.

POTENTIAL BENEFITS: More dependable unbaked standard products having better flavor and texture and new types of frozen dough products will increase customer satisfaction and the total consumption of bakery products. Within five years the decline in sales of frozen dough products since the peak in 1964 might be regained and exceeded by at least 20%. An upgrading in quality is expected equivalent to 2¢/lb. Sales of new sour dough products would add still more to this benefit.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
5	5

TITLE: New and improved pasta and extruded products. RPA 406-C.

SITUATION: Pasta and related extruded cereal products represent a low-cost source of attractive, nutritious food with wide adaptability and popularity. The consumption of these products in the United States is slowly increasing, as it is in many developed and underdeveloped countries, both on a per capita and a total basis. Product research has shown that an increase in the pasta market does not detract from other cereal products. Current raw material selection and production of pasta products rest on largely empirical practices, with the result that quality is unavoidably variable and costs are higher than necessary. Basic and applied research is required to remove these deterrents to the full growth potential of these popular products.

OBJECTIVE: To expand the consumption of wheat foods through development of improved, uniform high quality, and lower cost pasta products and processes.

RESEARCH OBJECTIVES:

A. Identify the physical and biochemical factors which contribute to and may govern the uniformity and high quality of pasta and related extruded products.

B. Determine the relationship of composition and structure of the wheat kernel and its milled products, both as entities and as combinations with other ingredients, to the esthetic, nutritional, and physiological responses of consumers.

C. Develop new methods and processes to simplify production and to enhance nutritional and esthetic values of these products.

POTENTIAL BENEFITS: Expanded use of higher quality products would increase financial returns to growers, processors, and merchandisers and would lead to greater consumer satisfaction at lower costs. A doubling within 10 years of the 7 lb. per year per capita consumption of pasta products appears achieveable and would increase the high return domestic market for wheat. At least half of this rate of growth could be attributed to the research proposed.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
3	4

TITLE: Improved malting processing and products. RPA 406-D.

SITUATION: Malts derived from cereal grains have been used traditionally for beverages, baked goods, and specialty food products. The byproducts are utilized mainly by the animal feeding industry. Malts are highly nutritious and flavorful, and they impart desirable organoleptic properties to foods when added as adjuncts. Barley is the primary cereal used, although wheat is used also. To make malt more economically attractive to the food processing industry and to provide more nutritious and palatable foods at low cost, several major improvements in the malting process are necessary. The time involved in the malting process should be decreased appreciably; this would decrease costs. Improvements in the present products and the development of new uses and products are needed. If these goals can be realized, a lost cost, highly nutritious, and stable food source could be added to the food supplies of the United States and the World.

OBJECTIVE: To obtain greater food uses for barley, wheat, and other cereal malts and reduce processing costs.

RESEARCH APPROACHES:

A. Develop new germination techniques to improve efficiency, to reduce the time required for the malting process, and to reduce malting loss. Areas of investigation include: embryo activation, enzyme development in aleurone cells, and water sensitivity and penetration of cell structures.

B. Investigate cheap and efficient means of water removal from "green malt" to create malts having unique properties for foods.

C. Determine physical and biochemical changes brought about by A and B.

D. Investigate the feasibility of using cereal malts as sources of

enzymes for food and industrial purposes.

E. Cooperate with industry in pilot plant studies concerning new developments brought about by this research.

POTENTIAL BENEFITS: Through changes in malt production and processing, low cost ingredients would become available for expanded high-return food use of barley, wheat, and other grains which would increase grower and processor income and would provide consumers with new and improved products.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
3	4

TITLE: New methods to fractionate wheat and other small grains. RPA 406-E.

SITUATION: New approaches to milling processing could produce a wide variety of new special wheat and other grain fractions for use in the food field. Possible new techniques include peeling, slicing, and electrostatic separation, alone or in combination with present conventional processes. Laboratory studies on new milling and processing techniques indicate possibilities for producing additional food fractions from raw and precooked wheat, for example, in the form of flakes, grits, and powders to be used in breakfast cereals, gruels, soups, and beverages in addition to present conventional uses. Existing milling techniques need to be improved, refined, and updated, and new approaches to the milling fractionation of small grains and the subsequent processing of their endosperm and nonendosperm fractions are required to aid in development of such food products.

OBJECTIVE: Modification of present milling procedures and development of new processes for milling and fractionating wheat and other small grains to provide simpler, less costly, or superior materials for new and improved food products.

RESEARCH APPROACHES:

A. Modification of present milling procedures to increase the range and yield of food fractions.

B. Improvement of present dry-milling procedures for fractionating flour, or nonendosperm parts by fine grinding and air classification, or by other physical processes.

C. Development of new and unconventional processes for producing flour fractions.

POTENTIAL BENEFITS: Increased income to growers and processors will result from greater high-return food use of wheat and other grains through development of methods to separate new fractions and more efficient methods to separate conventional fractions in higher yield. A 2% increase in flour extraction rate (from 72.4% to 76.2%) is projected. Additional benefits would result from a doubling, by use of improved methods, of the 10 million cwt. of flour presently fractionated to obtain special food fractions. New types offractions for food use would increase wheat food usage.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
6	5

TITLE: Enzymes or enzyme-derived products from wheat and other small grains. RPA 406-F.

SITUATION: Industrial processing through use of enzymes is becoming increasingly sophisticated, often with large scale and complex transformations supplementing chemical processing. Cereal grains and their fractions are attractive substrates for new or improved food applications for enzymes. For example, preliminary studies indicated that a microbial rennin can be produced by growing fungi on wheat flour and bran. Due to shortage of calf stomachs and increased production of cheese, the present cost of rennet solution is about $20 per gallon. Also, the conversion of starch to dextrose and sirup is carried out batchwise by a combination of acid and enzyme hydrolysis. If a continuous duo-enzyme process can be developed, lower-cost products can be obtained. If a suitable glucose isomerase can be immobilized on a support, a continuous process may be developed for producing fructose to give sweeter sugars and sirups from starches, including those of wheat and other small grains.

OBJECTIVE: Develop practical processes for obtaining new food enzymes, for continuous enzymatic conversions of wheat or other grain starches to new sweeteners, and for other enzymatic or fermatative processing of grain materials into new food products.

RESEARCH APPROACHES:

A. Survey microorganism collection for producers of rennin-like enzymes and develop a process for such products.

B. Develop a continuous process for the conversion of starch to dextrose and glucose sirups by use of immobilized enzymes.

C. Develop a continuous process for isomerizing glucose to fructose by immobilizing the enzyme system on a support.

POTENTIAL BENEFITS: Lower cost and more efficient enzymatic processing of grain starches or byproducts will increase returns to processors and growers and will result in lower costs for consumers. Rennet from calves' stomachs is currently valued at $6 million annually, and over $500,000 of the enzyme was imported in 1963. A microbial enzyme produced to sell at one-half the price of rennet from calves' stomachs seems feasible. A reduction in production costs of 0.25¢/lb. of the 4 billion lbs. of dextrose and glucose sirup produced annually appears feasible by improved processing. Wheat starch would be suitable for this use. Development of sweeter sugars from starch could easily direct at least 5% of the 20.6 billion lbs. current market for sucrose to lower priced starch sugars with enhanced sweetness. The annual reduced consumer costs and increased sale of starch-derived sugars should not be overlooked.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
8	12

TITLE: Modifications and processes for efficient use of small grain starches and flours in paper. RPA 407-A.

SITUATION: Some 25 million pounds of wheat starch per year are now used by the paper industry. Very little wheat or barley flour is used by the paper industry, primarily because technology for this application has not been developed. High-yielding strains of wheat that may be grown competitively with corn as a feed grain are being developed. This wheat is especially suited for the Pacific Northwest area where corn is not grown. Barley is also grown extensively there. There are many paper mills in that area, and need for technology to use starches and flours produced in that area has materialized. Much of the starch and flour now used comes from imported tapioca (300 million pounds currently imported each year).

Development of (a) acid-modified flour, (b) cationic starches and flours, (c) starch and flour xanthides, and (d) starch graft copolymers for use as sizing agents, wet-strength agents, and wet-web strengthening agents offer promise for use in paper manufacture.

OBJECTIVE: To develop low cost derivatives of starches and flours from wheat and barley for such specific applications in the pulp and paper industries as coatings, sizings, web-strengtheners, and wet-strength enhancers in order to increase the industrial utilization of these grains.

RESEARCH APPROACHES:

A. Determine optimum conditions for reacting acid with wheat and barley flours by fluidized bed process to yield products for surface sizing of paper.

B. Determine the effect of functional groups on cationic activity of starch and flour, and study cationic-inducing reactions to produce an economic product for use in coating and sizing paper.

C. Study reactions of ethylenimine with flours and interaction of protein and starch in flours to produce lower cost coating and sizing agents for paper.

D. Study the basic reactions for preparing starch and flour xanthates and incorporating them into paper by crosslinking reactions.

E. Prepare a wide variety of graft copolymers of starch and determine the most active and economical products for strengthening the wet-web during paper manufacture.

POTENTIAL BENEFITS: Increased use isforeseen of wheat and small grain flours and starches in the manufacturing of paper, particularly in the West Coast area where soft wheats and barley can be a more economical source of raw material than corn and milo. The magnitude of this may be given as follows:

A. About 500,000 lb. of acid-modified flours are produced annually, a small part of the 75 million lb. potential market.

B. By 1970 the projected demand for cationic starches and flours is 100 million lb. per year. Cationic cereal flours costing $0.02/lb. less than refined starches seem feasible.

C. Conservatively, 20 million tons of paper could be improved by use of starch xanthides. At a 5% application level, 1 million tons of starch xanthate would be needed at considerable saving.

D. Consumption of newsprint in the U.S. in 1967 was approximately 8 million tons at about $138 per ton. Savings would accrue from a 25-percent increase in production rate due to addition of a graft copolymer as a wet-web strengthener. In addition, it is likely that greater proportions of ground wood could be used in newsprint. Even greater savings could be achieved with other types of paper.

RESEARCH EFFORT:

	TF RECOMMENDATION	
	1972	1977
	13	12

TITLE: New polymers for coatings, adhesives, thickeners, and plastics. RPA 407-B.

SITUATION: Some 150 million pounds of wheat flour and 50 million pounds of wheat starch per year are now being used as sizing agents (other than in paper) and as adhesives for wallpaper, plywood, and composition board. To increase this uage requires development of technology based on new modified starches and flours to impart new properties, such as water resistance, improved solubility or dispersibility, paste viscosity, bond strength, tack, and drying time. Opportunities for modifying starches and flours for increased industrial applications are apparent in several end-use areas.

OBJECTIVE: To convert starches and flours into new polymeric products, such as starch-petrochemial copolymers, microbial polysaccharides and various chemically, physically, and enzymatically modified starch products, for use as water-resistant adhesives, industrial thickening agents , foamed plastics, coatings, and sizing agents.

RESEARCH APPROACHES: Emphasis will be placed on (1) more efficient utilization of the nonfood fractions of wheat and small grains, (2) nonfood wheats that can be grown in areas that do not produce corn, and (3) high-starch fractions of wheat and barley flours produced by air-classification.

A. Develop graft copolymers of starch which are effective thickening agents for water used in secondary oil recovery operations, flocculating agents for mineral ores and for suspended inorganic and organic matter in industrial waste waters, and latexlike graft copolymers of starch for use as adhesives in clay coatings on paper and paperboard.

B. Establish the practical potential for water-soluble hexosamine-containing (cationic) polysaccharides, discover and evaluate neutral water-soluble microbial polysaccharides, and seek microbial sources of galacturonic acid-containing polysacolloids.

C. Determine the value of starch-derived polyols for use in urethana plastics andcoatings.

D. Investigate the use of starch and flour derivatives in the rubber masterbatching process to produce elastomeric products with useful properties.

E. Evaluate dialdehyde starch-protein glues for specific uses.

POTENTIAL BENEFITS: Increased industrial use of wheat and small grains by new polymeric products from starches and flours would increase returns to farmers, industries, and labor in grain growing areas where corn cannot be grown or shipped profitably. Annual savings of large magnitude could be obtained from starch-derived viscosity agents for secondary recovery of petroleum; from new flocculants; from new starch-derived adhesives; drilling

mud stabilizers; starch-derived polyols in plastics and coatings; replacement of carbon black, silicas, and resins in rubber; and plywood glue. Low cost derivatives of wheat and small grain starches and flours could participate in these uses.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
13	15

TITLE: Processes to enhance the nutritive value of wheat and other small grains and their milling fractions for livestock and poultry feeds. RPA 407-C.

SITUATION: Feed grains and fractions from them provide energy, protein, and other nutrients for the production, growth, and maintenance of animals. Wheat and barley are widely used in animal feeds, but are slightly less efficient nutritionally than corn in practice. Even though a figure of 4.2 K calories/gm may be the laboratory-determined value for the gross energy of grains, not all this energy is nutritionally available to a ruminant animal. Energy and nutrients not absorbed during passage through the animal are wasted, and may amount to from 7 to 20% of the grain fed. Further the energy content of some feedstuffs is too low to allow them to be used as major ration components for poultry. Wheat bran and certain other milling fractions fall in this category. In the laboratory the metabolizable energy (ME) and nutritive quality of wheat millfeeds can be increased through processing. Steam pelleting wheat bran increased its ME by 31% and improved the biological availability of its phosphorus and amino acids. Feed efficiency of wheat millfeeds increased 16% when they were moistened and allowed to dry slowly. Treatment of Western whole wheats and barleys by the same wetting and drying process gave similar improvement in feed efficiency. Currently, grain is broken down by grinding, cold rolling, steam flaking, pressure cooking, etc. to make its nutrients more available, but process conditions to optimize the nutrient availability of wheat andbarley have not been established. Why processing improved feed efficiency and whether further improvement is possible are not known in most cases. Some grains contain anti-nutritional factors for poultry, like the beta-glucans in barley and the amylase and trypsin inhibitors in wheat products. Others undoubtedly exist and should be discovered and eliminated through processing. New cereal varieties and crosses (Mexican wheats, triticale) show great potential for feed use. The effect of processing on the nutritive qualities of these new feed grains also needs to be investigated.

OBJECTIVE: To develop processing treatments for wheat and other small grains that will increase utilization of their energy and other nutrients by ruminants and monogastric animals.

RESEARCH APPROACHES:

A. Compare physical processing treatments (hot air expansion (popping, steaming, rolling, cooking) that enhance nutrient qualities of grains for ruminants.

B. Investigate chemical treatments to increase nutrient qualities of grains for ruminants.

C. Investigate potential anti-nutritional factors in wheat and other small grain products.

D. Develop practical chemical, physical, or combination processes for greatest enhancement of nutrient quality of small grains for ruminants.

POTENTIAL BENEFITS: Greater use of wheat and other small grain products in poultry, swine, and ruminant feeding will lead to lowered production costs in many areas of the United States and increased utilization of these grains. Reasonable success in achieving the goals of this research would give benefits from a 10% increase in the efficiency of barley and wheat utilization by ruminants. Parametric least-cost linear programming data for poultry feeds indicate that each increase of 100 K cal/lb is worth 2¢ for low energy feedstuffs. Increasing the available energy in wheat millfeeds thru processing would give an increase of 400 K cal/lb, amounting to $16/ton. Allowing $3/lb for processing costs, a net savings of $13/ton can be achieved. A 25% increase in the availability of the phosphorus in millfeeds through processing might be achieved. Also feed efficiency of western whole wheats and barleys increased by 2%. If processing costs were reasonable, a cash saving would be achieved on 8 million tons of these grains fed to monogastric animals annually.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
12	15

RESEARCH PROBLEM AREAS FOR MARKETING OF CROPS

TITLE: Quality maintenance of wheat and other small grains and their products during marketing. RPA 408.

SITUATION: Wheat, other small grains and their products are subject to deterioration resulting in an economic loss between harvest time and consumer use. Development of new production and harvesting technology for small grains creates new problems in storing and handling of these grains. Information is needed on the effect and control of temperature, humidity, and atmosphere and on the control of microorganisms and insects in storage. Methods are needed to detect quality deteriorating factors including chemicals residues, mycotoxins and internal insects. Deterioration of grains may occur as a result of physiological processes. Research is needed to determine the extent of this type of deterioration under different environmental conditions.

The effect of one microorganism on another under different environmental and nutritional conditions is not understood. Often one fungus gains dominance over another. A better understanding of these interactions could result in non-chemical control of microorganisms in stored grains. The exact moisture and humidity requirements of fungi at various temperatures and the effect of various drying, handling, and insect treatments on these requirements are not known.

Presence of insects creates a favorable environment for fungus development. Further research is needed on the interrelationship of insect infestation and mold damage to develop methods for controlling both.

For more efficient control of insects in stored grains, research is needed on the biology, ecology and physiology of insects that infest small grains and the effect of the composition of the grain mass on the insect population. Also, for the control of insects infesting small grains, research is needed on the use of controlled climatic and atmospheric factors for protecting grain, development of nonpesticidal and/or pesticidal control measures.

The use of pesticides to control insects cannot be considered static. Some fumigants now in common use may not be permitted in the future and insects develop resistance to specific insecticidal compounds. Recent technological advances in insect attractants and chemosterilants hold considerable promise for developing an entirely new system of controlling stored-products insects. There is good reason to believe that imaginative and vigorous research can combine the elements of sex attractants, a trap, and chemosterilants into an integrated system that would be highly effective, safe, simple, and economical.

A considerable increase in recommended research effort has been projected for 1972 and 1977 over that recommended in "A National Program of Research for Agriculture." This Task Force has taken into consideration the staffing of the U.S. Grain Marketing Research Center to be built at Manhattan,Kansas,

and scheduled for staffing in Fiscal Year 1971

OBJECTIVE: To determine optimum environmental conditions for the storing, handling and marketing of wheat, other small grains and their products during the marketing process.

RESEARCH APPROACHES:

A. Investigate the influence of one microorganism on another under different exacting environmental conditions.

B. Develop techniques, instruments, and procedures for detecting and measuring chemical residues, presence of insects, and other contaminants affecting quality.

C. Develop practical and objective methods of determining quality attributes of small grains and their products.

D. Develop biological, physical andchemical measures of controlling microorganisms and insects, including the development of improved measures for the safe, economical, and effective use of conventional-type insecticides.

E. Investigate the influence and interactions of insects and microorganisms on one another.

F. Study the biology, ecology, and physiology including the nutritional requirements of insects that infest small grains.

G. Develop methods of determining physiological deterioration of small grains and study the extent of this type of deterioration under different environmental conditions.

H. Cooperate with industry to translate results of these researches to marketing practices.

POTENTIAL BENEFITS: Conservation of quality and reduction in product loss during marketing will be achieved. Development of non-chemical control measures of insects and microorganisms not only would reduce product loss but would minimize the danger of chemical residues. The results of this research should facilitate marketing transactions through more accurate description of products and more precise measurement of quality attributes. Savings resulting from the research described above would benefit producers, processors, and consumers nationwide.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
36	46

TITLE: Development of new and improved criteria, methods and technology for grading wheat and other small grains. RPA 501.

SITUATION: Grades and standards in the marketing system should provide meaningful communication with respect to quality of a product in relation to its price and use. Objective, quick, and accurate measures for characteristics of economic significance are needed, along with increasing automation in the use of this information. Wheat, barley and oats are traded in the U.S. on the basis of official grades, which are determined by factors including test weight, moisture, damaged kernels, and foreign material. Protein content is used in marketing wheat and malting barley but it is not a part of the official grain standards. Low cost and accurate methods of testing for protein content at country buying points are not available. A system of grades and standards recognizing protein content, milling yield, and other meaningful quality factors should be developed and established.

Again, as in RPA 408, the increase in recommended research effort is based on the projected staffing of the U.S. Grain Marketing Research Center scheduled for Fiscal Year 1971.

OBJECTIVE: To provide grades and standards that will effectively communicate value differences for varying gradations of quality. Less loss of the product due to more accurate analysis of quality factors such as moisture content.

RESEARCH APPROACHES:

A. Evaluate the effectiveness of existing grades and standards in serving the needs of sellers and buyers and for reflecting different gradations of quality which affect value and use.

B. Develop descriptive terminology for grades and standards which will characterize the different attributes of wheat, other small grains and their products so as to facilitate communication between buyers and sellers.

C. Develop methods and establish a uniform system of grades and standards recognizing those characteristics which reflect value and affect use.

POTENTIAL BENEFITS: Improved communication would result through more precise terminology and methods for describing and assessing varying gradations of quality. Prices would more accurately reflect value and a more competitive position in marketing small grains in the world market would result. Decreased sampling and sample analysis costs and more reliable inspection would be major benefits. Complete and reliable automated sampling and grading of wheat and other small grains is needed to decrease Federal inspection costs, reduce boxcar time, and reduce costs in boxcar trimming, losses due to downgrading, and inaccurate sample analyses.

RESEARCH EFFORT:	TF RECOMMENDATION	
	1972	1977
	9	10

TITLE: Maintenance of physical condition and economic efficiency in marketing small grains. RPA 504A.

SITUATION: Ninety percent of the 1.3 billion bushels of wheat and a considerable portion of the barley, oats and other small grains harvested each year in the U.S. moves through marketing channels to the processor and consumer. Movement of wheat in larger lots such as the Big John Hopper cars and ships in the export market have created new handling procedures. Grain is now handled at high flow rates which causes grain breakage resulting in lowering of the quality and makes the grain more susceptible to mold and insect attack. Research is needed in evaluating grain handling equipment and modifications thereto to form a basis for developing design criteria of new equipment that would cause less physical damage to the grain.

Wheat and other small grains continue to be harvested at higher moisture levels and at faster rates each year. The result is a tremendous flow of grain into large storage facilities in a short period of time which taxes conventional grain conditioning and drying systems.Research is needed in developing design criteria for improved equipment and techniques that will condition the grain at a faster rate, less costly, and without causing damage to the grain.

Little is known about the rheological, physical, optical and electrical properties of wheat and other small grains. Basic studies are necessary in this area in order to formulate fundamental theories for the development of new and different design criteria for grain handling equipment that will move grain at higher flow rates without causing physical damage to the grain.

The large part private industry plays in the development of grain handling, conditioning, storage, and transport equipment is recognized. The work done by federal and state workers has been in the past and will be in the future coordinated with the efforts of private industry to assure that the basics developed by the federal and state workers is applied to the development of new equipment by private firms.

The recommended research effort includes the increase projected for the staffing of the U.S. Grain Marketing Research Center as explained in RPA 408.

OBJECTIVE: To develop criteria for more efficient work methods, devices, equipment, facilities, and transportation systems, for conditioning, storing and handling wheat, other small grains and their products in market channels.

RESEARCH APPROACHES:

A. Evaluate the effectiveness of current handling procedural and equipment; develop criteria and test modifications of equipment to minimize physical damage to wheat and other small grains.

B. Develop criteria and improvements in equipment and techniques to condition moist wheat and barley.

C. Determine rheological, physical, optical and electrical properties of wheat and other small grains to provide a basis for design of improved equipment and facilities.

D. Develop design criteria and improved storage layouts, and improvements in equipment that economically provide recommended storage environments.

POTENTIAL BENEFITS: Reduced labor costs, reduced transport costs, reduced operating costs, minimum facility construction costs, and minimum loss in product quality and minimum transport losses are the benefits expected.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
11	12

TITLE: Physical and economic efficiency in marketing small grains. RPA 504-B.

SITUATION: Recent expansion of wheat and small grain production has been accompanied by shifts in market channels and outlets for both wheat and flour. These shifts have been due largely to an overall increase in commercial andgovernment-financed exports and to changes in patterns of national and international demand. Changes have also resulted from revisions in the transportation rate structure and the development of alternative modes of transportation. Processing technology, the structure of transportation rates, and other economic factors affecting costs may interact to foster marketing inefficiencies in the wheat and small grain industry. Adjustments may be needed in the location, size, and number of processing plants because of changes in production areas and demand patterns.

OBJECTIVE: To obtain information necessary for establishment of an effective but flexible marketing system that can operate at optimum efficiency under everchanging conditions.

RESEARCH APPROACHES:

A. Determine the most efficient and economical system for handling, transporting, storing, and distributing current and projected supplies of wheat, small grains, and their products including the type, size, and location of facilities.

B. Evaluate the overall structure and performance of wheat and small grain markets including studies of prices and marketing costs,

margins, practices, and services.

C. Evaluate the economic impacts of marketing innovations, new or improved products, and market development activities on wheat, small grains, and their products in both domestic and foreign markets.

POTENTIAL BENEFITS: Reduce the total cost of producing, delivering to primary markets, processing, and distributing the national wheat and small grain crop and thereby save resources for increasing real national income. A saving in marketing costs of 1 percent of the farm value would be immense, and more saving is probable.

RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
8	8

Other Research Problem Areas of Concern to this Task Force

The satisfactory production, marketing and use of the small grains depends upon research from a still broader base than already given in this report. Specific attention is called to RPA 601 (expansion of foreign markets), 702 (protection of foods) and 901 (pollution), and full statements on some aspects of the work in these areas have been sent to other Task Forces for consideration.

This Task Force is fully aware of the need to have active, progressive research in the following, and possibly other, RP areas:

102 - Soil structure; and soil, plant, water, nutrient relationships

103 - Management of salinity and saline soils

105 - Conservation and efficient use of water for agriculture

109 - Weather effects, probabilities, and agricultural decision making

214 - Protection from harmful effects of air pollution

311 - Feed efficiency in production of meat, milk and eggs

316 - Farm adjustment and management

506 - Supply, demand, and price analysis

507 - Competitive interrelationships in agriculture

508 - Development of domestic markets for farm products

511 - Improvement of agricultural statistics

601 - Expansion of foreign markets for U.S. farm products

603 - Technical assistance to developing countries

701 - Insure food products free from toxic residues

702 - Protect food supplies from harmful -- (external agents)

708 - Human nutritional well-being

901 - Alleviate soil, water, and air pollution

Certainly, studies on the soil, plant nutrition, salinity and variety productivity, and adaptation are extremely important to solving problems associated with small grain production. Likewise, research on our water,

air, and weather resources is of growing significance. Larger, more varied, and more competitive markets for grain are urgently sought. The opportunity to improve the quality and devise new uses of our grains have been outlined in this report but the expanded markets, especially foreign markets, must be found, opened up, and held.

Yet other research problem areas have pertinence to wheat and small grain problems. These are the more general areas such as RPA 509 (marketing firm efficiency) in which numerous commodities, including grains, are involved, from which useful information comes to help with grain problems. Often too, grain specialists would expect to cooperate with scientists in other research problem areas to appraise economic implications and research results.

Therefore, as research develops in these areas, wheat and the other small grains should be included in a manner appropriate to the magnitude of the problem as it affects these crops.